Taking Steps Towards Walkability

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Introduction

Walkability is a measure of the extent to which the built environment is conducive to walking. It is well known that physical activity and walking have a wide range of health benefits, but most people in the United States fail to reach recommended amounts of physical activity in their daily lives[1]. One way to resolve this issue is to modify the built environment of neighborhoods to allow greater opportunities for walking. Other public health interventions to increase physical activity may involve programs that require continued support and resources. Changing the built environment, however, does not require the same amount of upkeep. It has been shown that residing in a more walkable neighborhood is associated with better health outcomes including a lower risk of developing diabetes[2], a lower body mass index (BMI)[3], and a lower incidence of hypertension[4], via increased physical activity in adults[5-9].

Neighborhood walkability can be characterized in several ways. Previous walkability indices were created using distinct combinations of neighborhood-level indicators measured by geographic information systems; some of the most common of which include: population density[2,7,10,11], residential density[2,3,11-13], street connectivity[2,3,7], land use mix[3,7,12-14], access to public transportation[2,7,11,14], and intersection density[5,13]. Access to various types of facilities – such as parks, recreation centers, and retail stores – is also often used as an indicator[6,8,10-12].

Many existing analyses of walkability and its associations with health behaviors and health outcomes have used street-level data[7,8,10,12] while other studies have examined walkability at the county[9] and neighborhood[3] levels. No studies exist examining walkability at the city level. Researching walkability at the city level is important to examine because although cities are usually very walkable areas, they vary greatly in demographic characteristics. Examining these characteristics may reveal which population subgroups may be at risk for living in low walkability areas and what changes can be made to the built environment or access to community resources to alleviate these risks and facilitate a more walkable environment. In this study, we examined the association of city-level United States Census factors with community walkability. We hypothesized that walkability would have a positive association with income, age, and level of education.

Methods

We analyzed data from the 50 most populous cities in Ohio. We obtained city-level sociodemographic characteristics from the United States (US) Census; specifically, data from the 2011-2015 American Community Survey were used to characterize income (2015 1-year estimates), education (2014 5-year estimates), and age (2015 1-year estimates) (ref the Census website). All walkability data was obtained from walkscore.com,[15] which produces a Walk Score for each city using a point system based on the distances to amenities in different types of categories while also analyzing road metrics. Scores range from 0 to 100 points. City-wide scores were calculated by an algorithm which assesses the Walk Score of approximately every city block and weights those values by the corresponding population density. Research supports the use of a Walk Score as a valid way to determine neighborhood walkability[16].

We treated the Walk Score as a continuous variable in our primary analysis. As a secondary analysis, we stratified the Walk Score into categories according to walkscore.com.[15] We considered the categories of "car-dependent" (Category 1: range 0-24), "car-dependent" (Category 2: range 25-49), "somewhat walkable" (Category 3: range 50-69), "Very Walkable" (Category 4: range 70-89), and "Walker's Paradise" (Category 5: range 90-100). Categories 4 and 5 were not represented in our data, as none of the cities within our population had a Walk Score greater than 70. Age (median, years), education status (percent of residents between ages 18 and 24 with less than a high school education), and median household income (in the past 12 months in 2015 inflation-adjusted US dollars) were treated continuously in the analyses.

We calculated the distribution of each continuous variable in terms of its median, interquartile range, minimum, and maximum. We additionally calculated the mean and standard deviation for each city-level sociodemographic variable per the 3 Walk Score categories represented in our data. Next, we performed a linear regression to examine the association between age, education, and income with the Walk Score. We obtained crude and adjusted beta values and p-values for each association. We used JMP Pro (Cary, NC) Version 12.2.0 for all analyses. A p-value of 0.05 was used to determine the statistical significance of our results.

Results

For the 50 most populous Ohio cities, the median walk score was 33.5 (minimum 13, maximum 66, Table 1). Meanwhile, the median age was 38.05 years, with a maximum of 47.7 and a minimum of 22.9. The median age for Ohio's total population in 39.3. The median proportion of the population aged 18 to 24 with less than high school education was 15.8% (range 1-29%). The percent of Ohio's total population was 14.8%. The average median household income across all cities was $51,235.50, ranging from $23,984 to $129,772. The median for Ohio was $51,075.

Results from crude linear regression analyses demonstrated that both median age (p=0.22) and median household income (p=0.0095) were significantly associated with Walk Score (Table 2). Meanwhile, high school education was not associated with Walk Score. After adjusting for median household income and education, a 10-year increase in the median age of a city was associated with an 8.68-point decrease in Walk Score. After adjusting for median age and education, a $10,000 increase in median household income at the city level was found to be associated with a 1.97-point decrease in Walk Score.

We observed that as Walk Score category increased from 1 to 3, the median household income decreased in a dose-response fashion from $75,474.14 to $45,425.2 to $41,244.5, respectively (Figure 3). Similarly, as the Walk Score category increased, the median age also decreased from 41.5 to 37.3 to 35.9 years, respectively. However, as Walk Score increased, we observed an increase in the proportion of the population with less than a high school education across categories: from 13.06% to 16.24% to 17.28%.

Discussion

Among Ohio's 50 most populous cities, increases in median age and income were associated with decreases in Walk Score. The percent of city residents with less than a high school education was not significantly associated with Walk Score.

It was surprising that lower incomes were associated with higher Walk Scores. This trend could have been due to the increased population density of poorer neighborhoods. Wealthier families tend to live in households with a larger area of property which may decrease walkability. It is also unusual that both age and income were associated with Walk Score but education was not. This is surprising because increased age and income are typically associated with increased education. We speculate that this finding could be related to some cities having larger numbers of college students because of the presence of one or more universities. While college students often have low household incomes and are often of a young age, they have all graduated high school. Cities with larger proportions of college students may have influenced the outcome of our analysis. Our analysis was unable to confirm this hypothesis because census data does not contain information about the proportion of city residents who are college students.

Because studies on walkability typically compare walkability to the use of active transportation or health indicators, it is unknown whether our associations are consistent with other studies. More research is necessary to confirm the relationship between city level demographic characteristics and walkability.

Our analysis was unable to track real amounts of physical activity among residents. Actual physical activity may not perfectly align with Walk Score, although it is likely that they are closely related. Furthermore, walkscore.com does not take pedestrian safety into account when calculating a Walk Score. Pedestrian safety has been shown to influence the amount that residents walk for transportation[9].

The large range in Walk Score between cities (53) demonstrates that the variation among cities is much larger than originally predicted. Like their potential effect on education, colleges and universities might also have an influence on Walk Score. These areas are typically designed to be more walkable in order to increase accessibility for students who live in dorms or off campus.

In addition to having a variety of Walk Scores, the 50 cities that were studied are geographically very dispersed. This geographical range makes our findings more generalizable to the entire state. The median age, median household income, and percent with less than a high school education of the 50 most populous cities were very similar to the median age, median household income and percent with less than a high school education of Ohio's total population, further increasing generalizability.

A future direction we have considered for this work is to examine Walk Score by the county, zip code, or neighborhood level. We were limited by the availability of data, as Walk Score data were not available for zip codes or counties and census data were not available for neighborhoods. While these walkability indices can accurately reflect the built environment, the perceived environment also has an influence on walking for transportation[6,8,10]. For this analysis, we were unable to study public perceptions of walkability.

We found that walkability was associated with certain demographic characteristics. These associations should be kept in mind when designing public health interventions to increase physical activity. We

found that older populations who are more at risk for chronic disease tended to live in less walkable areas. Potential interventions for areas with older populations include activities like walking groups, where people are encouraged to walk recreationally with friends. We also found that lower income areas, where people are also more at risk for chronic diseases, tended to have higher walkability. However, these areas are also more likely to have higher levels of crime, which is associated with less use of active transport[9]. Efforts should be made in densely populated areas to increase pedestrian safety so that people are more inclined to walk for transportation. Changing infrastructure and creating programs that increase walkability will have significant positive effects on the health of the community and decrease risks for serious conditions like heart disease and diabetes.

Tables and Figures

Table 1. Median, IQR, minimum and maximum for each variable.

Variable	Median 50 most populous cities (IQR)	Minimum	Maximum	Ohio total population (margin of error)
Walkscore	33.5 (16.5)	13	66	Not Available
Median Age of Population (years)	38.1 (6.1)	22.9	47.7	39.3 (+/-0.1)
Percent Less than High School Graduate (%)	15.8 (7.4)	1	29	14.8 (+/-0.3)
Median Household Income	51,235.5 (27,487)	23,984	129,772	51,075 (+/-233)

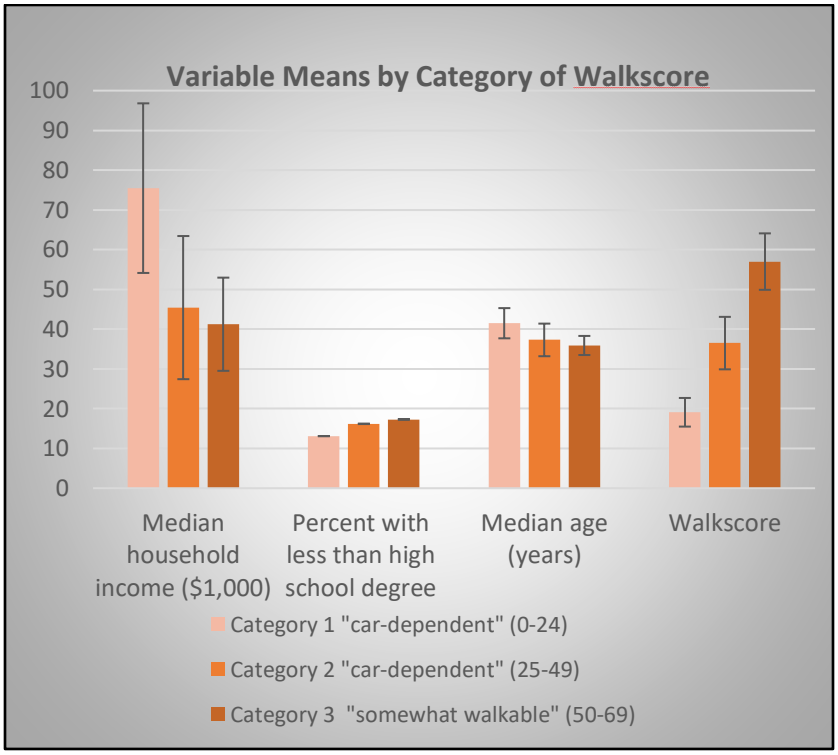
Table 2. Beta estimates and standard errors resulting from univariate (Model 1) and multivariable (Model 2) linear regression: walkability

	Model 1*		Model 2**	
	Beta (SE)	P value (crude)	Beta (SE)	P value (adjusted)
Intercept	-	-	74.0 (13.1)	<0.0001
Median age (10 years)	-14.1 (3.4)	0.0002	-8.7 (3.7)	0.02
Median household income ($10,000)	-3.0 (0.62)	<0.0001	-2.0 (0.73)	0.01
Percent with less than HS degree (1%)	48.9 (29.0)	0.99	20.2 (25.1)	0.42

*Model 1 represents univariate associations

**Model 2 is adjusted for age, median income, and education

Figure 3. Variable means and standard deviations for each variable stratified by category of walk score.



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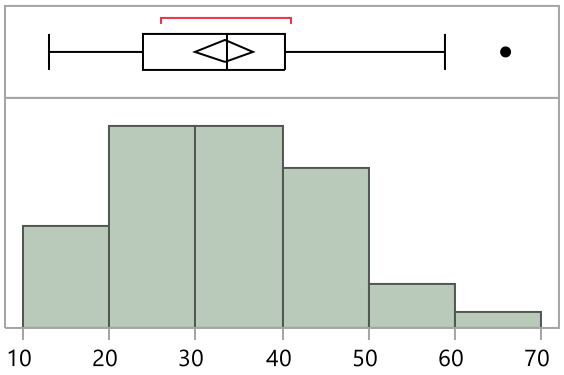
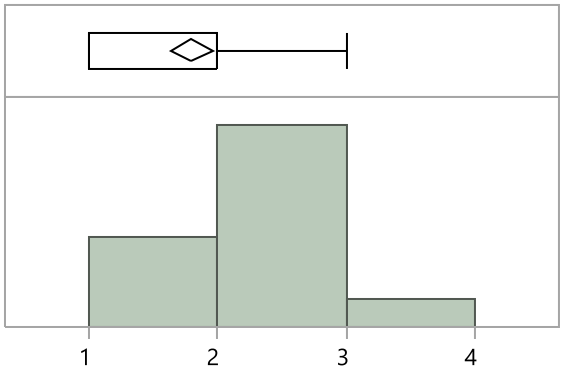
Appendix A. Variable Distributions for 50 Most Populous Ohio Cities

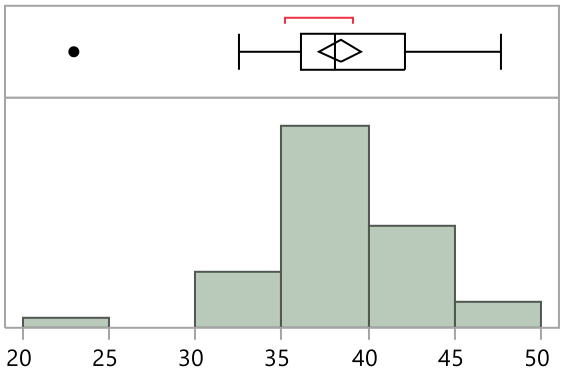
Continuous Walk Score



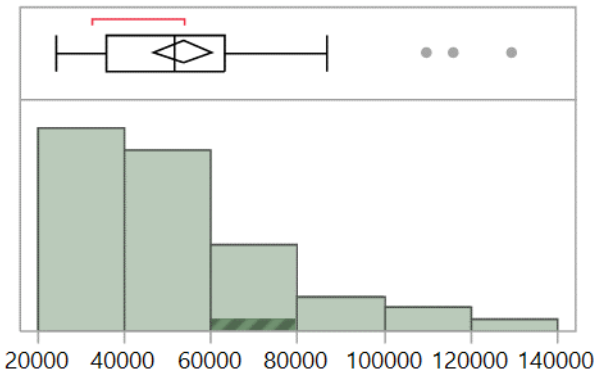
Walk Score categories



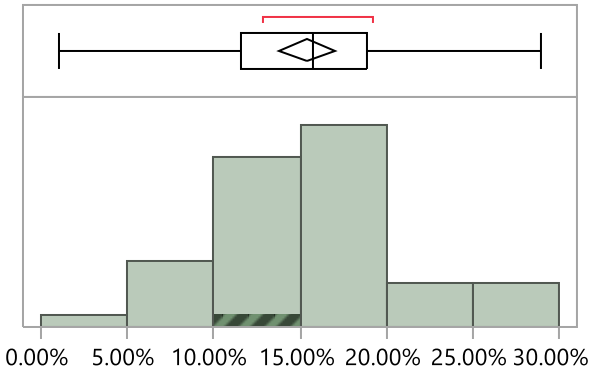
Median age



Median household income

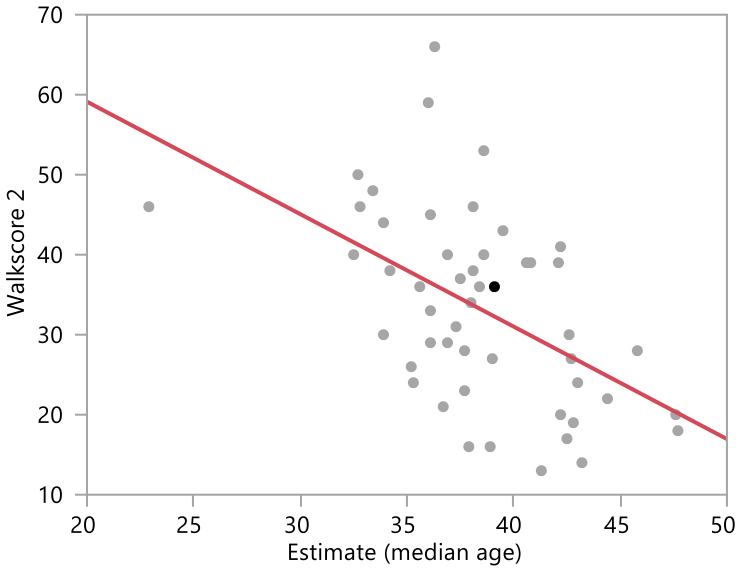


Percent of the population with less than a high school degree

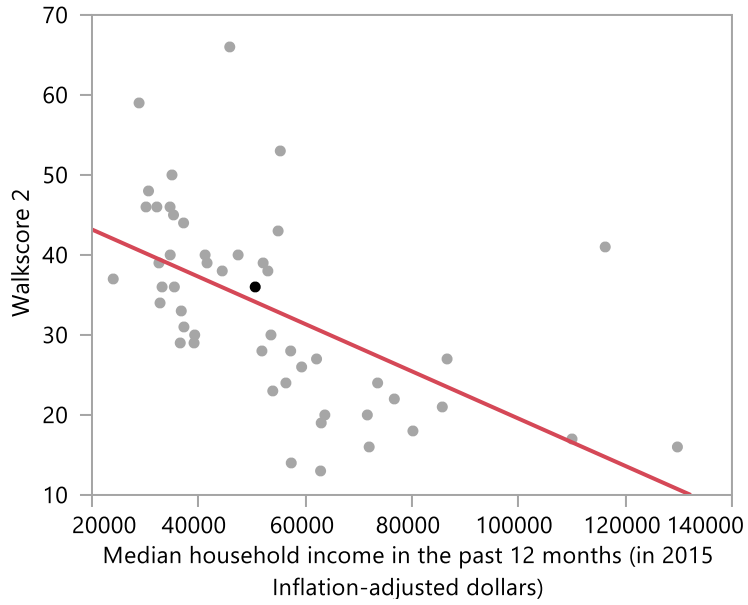


Appendix B. Univariate and Multivariate Linear Regression Models

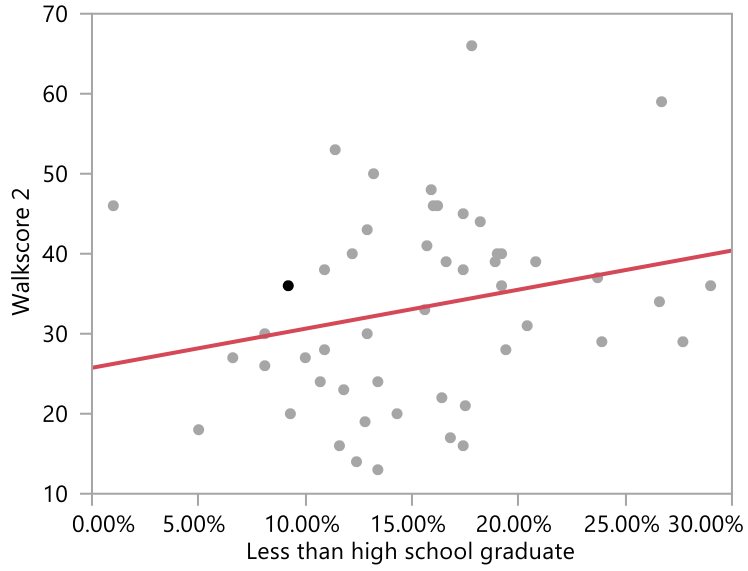
Univariate Walk Score and median age



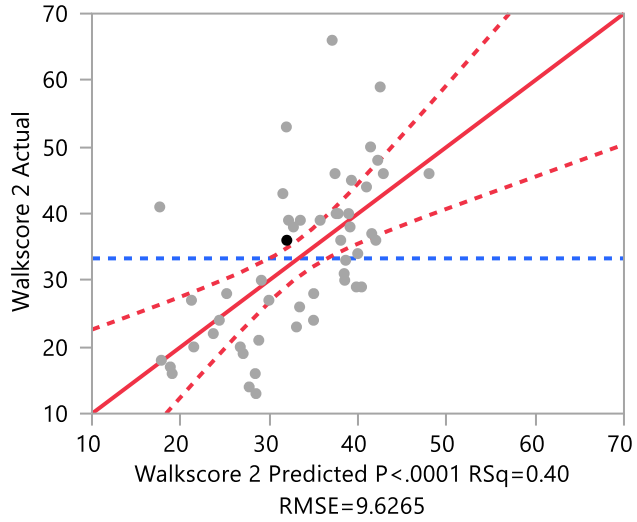
Univariate Walk Score and median household income



Univariate Walk Score and percent of the population with less than a high school degree



Multivariate adjusted for median household income, median age, and percent of population with less than a high school degree



Appendix C. Numerical values for means and standard deviations for each variable stratified by category of walk score

	Walk Score Categories			
		1	2	3
Median household income in the past 12 months (in 2015 Inflation-adjusted dollars)	Mean (SD)	75474.1 (21326.4)	45425.2 (18004.9)	41244.5 (11718.9)
Percent with less than a high school degree	Mean (SD)	13.1 (0.03)	16.2 (0.06)	17.3 (0.07)
Median age	Mean (SD)	41.5 (3.8)	37.3 (4.1)	35.9 (2.4)
Walkscore	Mean (SD)	19.1 (3.6)	36.5 (6.6)	57 (7.1)

Appendix D. Census and Walk Score Data for 50 most populous Ohio cities

	Estimate (median age)	margin of error	Less than high school graduate	margin of error	Median household income in the past 12 months (in 2015 Inflation-adjusted dollars)	margin of error	Walk Score	Walk Score Category
Akron city, Ohio	38.1	+/-1.5	16.20%	+/-1.9	34,639	+/-2,624	46	2
Beavercreek city, Ohio	38.9	+/-3.2	11.60%	+/-4.3	71,976	+/-11,917	16	1
Boardman CDP, Ohio	42.6	+/-4.3	12.90%	+/-3.8	53,560	+/-5,260	30	2
Bowling Green city, Ohio	22.9	+/-1.6	1.00%	+/-0.7	32,162	+/-8,642	46	2
Brunswick city, Ohio	42.2	+/-5.1	9.30%	+/-3.3	63,664	+/-10,266	20	1
Canton city, Ohio	33.4	+/-1.6	15.90%	+/-2.9	30,601	+/-3,825	48	2
Cincinnati city, Ohio	32.7	+/-0.8	13.20%	+/-1.3	35,001	+/-2,472	50	3
Cleveland city, Ohio	36	+/-0.8	26.70%	+/-1.4	28,831	+/-1,262	59	3
Cleveland Heights city, Ohio	38.6	+/-2.6	11.40%	+/-3.1	55,310	+/-3,476	53	3
Columbus city, Ohio	32.5	+/-0.4	12.20%	+/-0.9	47,401	+/-1,636	40	2
Cuyahoga Falls city, Ohio	39.5	+/-3.3	12.90%	+/-5.1	54,901	+/-4,769	43	2
Dayton city, Ohio	32.8	+/-1.4	16.00%	+/-1.9	30,135	+/-2,414	46	2
Delaware city, Ohio	35.2	+/-3.0	8.10%	+/-3.4	59,312	+/-11,637	26	2
Dublin city, Ohio	37.9	+/-1.3	17.40%	+/-5.2	129,772	+/-8,288	16	1
Elyria city, Ohio	36.1	+/-3.0	23.90%	+/-3.8	39,139	+/-1,710	29	2
Euclid city, Ohio	40.6	+/-4.4	16.60%	+/-4.8	32,557	+/-3,324	39	2

Fairborn city, Ohio	33.9	+/-2.6	8.10%	+/-3.0	39,261	+/-6,376	30	2
Fairfield city, Ohio	37.7	+/-5.1	11.80%	+/-4.5	53,901	+/-7,956	23	1
Findlay city, Ohio	39.1	+/-3.3	9.20%	+/-3.5	50,607	+/-3,490	36	2
Gahanna city, Ohio	43	+/-5.6	10.70%	+/-4.2	73,560	+/-6,565	24	1
Grove City city, Ohio	39	+/-5.8	10.00%	+/-4.0	62,107	+/-7,592	27	2
Hamilton city, Ohio	34.2	+/-2.9	17.40%	+/-3.3	44,424	+/-6,543	38	2
Hilliard city, Ohio	36.7	+/-4.9	17.50%	+/-5.5	85,685	+/-12,264	21	1
Huber Heights city, Ohio	35.3	+/-4.3	13.40%	+/-4.1	56,363	+/-6,441	24	1
Kettering city, Ohio	38.1	+/-1.8	10.90%	+/-3.0	52,979	+/-3,400	38	2
Lakewood city, Ohio	36.3	+/-2.4	17.80%	+/-4.2	45,836	+/-3,298	66	3
Lancaster city, Ohio	36.9	+/-1.9	19.20%	+/-5.6	41,211	+/-3,296	40	2
Lima city, Ohio	33.9	+/-2.2	18.20%	+/-3.8	37,178	+/-5,633	44	2
Lorain city, Ohio	35.6	+/-2.7	29.00%	+/-5.9	35,447	+/-2,823	36	2
Mansfield city, Ohio	36.9	+/-3.4	27.70%	+/-4.5	36,548	+/-3,980	29	2
Marion city, Ohio	38	+/-3.2	26.60%	+/-5.3	32,762	+/-2,706	34	2
Mason city, Ohio	42.5	+/-3.1	16.80%	+/-6.9	110,008	+/-33,023	17	1
Massillon city, Ohio	42.1	+/-6.1	20.80%	+/-5.5	41,577	+/-3,151	39	2
Mentor city, Ohio	47.6	+/-2.7	14.30%	+/-4.9	71,627	+/-9,320	20	1
Middletown city, Ohio	37.3	+/-3.3	20.40%	+/-4.5	37,241	+/-3,776	31	2
Newark city, Ohio	36.1	+/-3.6	15.60%	+/-3.8	36,741	+/-5,540	33	2
North Olmsted city, Ohio	45.8	+/-3.3	10.90%	+/-3.7	57,259	+/-9,148	28	2
North Ridgeville city, Ohio	41.3	+/-3.0	13.40%	+/-4.9	62,865	+/-8,334	13	1

North Royalton city, Ohio	43.2	+/-6.1	12.40%	+/-5.5	57,363	+/-10,052	14	1
Parma city, Ohio	40.8	+/-1.9	18.90%	+/-3.3	52,093	+/-4,263	39	2
Reynoldsburg city, Ohio	37.7	+/-5.1	19.40%	+/-5.2	51,864	+/-5,486	28	2
Springfield city, Ohio	38.6	+/-2.5	19.00%	+/-2.8	34,668	+/-4,263	40	2
Stow city, Ohio	42.8	+/-6.9	12.80%	+/-4.0	62,983	+/-10,599	19	1
Strongsville city, Ohio	47.7	+/-4.8	5.00%	+/-2.4	80,181	+/-6,541	18	1
Toledo city, Ohio	36.1	+/-0.8	17.40%	+/-1.3	35,289	+/-1,344	45	2
Upper Arlington city, Ohio	42.2	+/-3.7	15.70%	+/-6.1	116,235	+/-9,558	41	2
Warren city, Ohio	38.4	+/-3.5	19.20%	+/-3.6	33,143	+/-2,495	36	2
Westerville city, Ohio	42.7	+/-4.2	6.60%	+/-2.4	86,582	+/-11,221	27	2
Westlake city, Ohio	44.4	+/-4.0	16.40%	+/-4.9	76,690	+/-8,405	22	1
Youngstown city, Ohio	37.5	+/-2.2	23.70%	+/-3.1	23,984	+/-2,568	37	2